PECAS - for Spatial Economic Modelling

SCAG modeling status and next steps

System Documentation Technical Note
WORKING DRAFT

HBA Specto Incorporated

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1. Introduction

A Spatial Economic Model has been constructed for the Southern California Region. The model is based on the PECAS (Production – Exchange - Consumption Allocation System) framework, and covers the area under the influence of the Southern California Association of Governments (SCAG).

The model was commisioned by SCAG and built by SCAG together with the Urban Land Use and Transportation (ULTRANS) Center at the University of California, Davis, and HBA Specto Incorporated in Calgary, Alberta. The model is based on a statewide PECAS model being developed by ULTRANS and HBA, and has been modified to make it more specific to the Southern California region.

An iterative development approach is being taken, where successive versions of the model are more accurate and more useful to SCAG. This document describes the current model which has been developed specifically for SCAG, and has been run with several scenarios to demonstrate its functionality and to prioritize the next steps in its planned development.

Section 2 of this document describes some of the work that has been done in developing the current model. Section 3 shows results from the current model, showing the outputs for several scenarios and comparisons between the scenarios. Section 4 lists some of the limitations of the current model, and describes the next steps that should be undertaken to further improve the model. Section 5 offers conclusions.

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2. Previous accomplishments

A number of steps were completed in the construction of the current SCAG PECAS model. These included technical work on the model itself, processing data or installing and adjusting software, as well as technical training to the SCAG staff to enable SCAG staff to develop, understand and apply the model.

2.1. Statewide install

The existing statewide PECAS model was installed on SCAG computers, demonstrated to SCAG staff, and setup so that SCAG staff could continue to run the Statewide model.

2.2. Select out SCAG Region

The statewide model was trimmed down so that only the SCAG region was represented. This was the first version of a SCAG specific model, with a representation of the SCAG economy and SCAG land use.

2.3. Setup SCAG zone system

The zone system for the SCAG region was selected, based on existing boundaries used by SCAG.

2.4. Integrate with SCAG skims from transport model

The indications of travel distance and cost from the statewide model were replaced by the indications from the SCAG travel models.

2.5. IMPLAN reprocessing

The processing of the data from the IMPLAN model, which determines the nature of the economic relationships, was re-done with a SCAG specific IMPLAN. Several consistency checks were automated and some of the processing was further documented. As a result the categories of industry are based on proportions from the SCAG region, and further iterations of the model can more easily experiment with alternative designs.

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2.6. Install PostgreSQL system

The database system used for the parcels in the Space Development (SD) module is based on the PostgreSQL software. PostgreSQL functions well as a temporary datastore for large quantities of data, ensuring relational integrity and flexible access to data. PostgreSQL is also an enterprise level database with powerful spatial extensions (PostGIS), making it well suited to serving model results to other computers in the SCAG building.

2.7. Tune PostgreSQL system

The PostgreSQL database software's default configuration is designed for rapidly serving many small quantities of data. Changes need to be made to its configuration to make it perform well when the PECAS Space Development (SD) module is inspecting and possibly changing every parcel in the SCAG region; the changes are specific to the computing hardware used.

2.8. Parcel based layer for Space Development Module

The parcel database from the SCAG GIS system was brought into the PECAS model, to replace the grid based system from the statewide model. The parcel database was processed and loaded into a PostgreSQL database, which provides a stable and flexible data storage system, relational integrity between the tables, and connects the parcels with their GIS information through the PostGIS extensions of PostgreSQL.

2.9. Zoning layers

The zoning information from the SCAG region was reformatted and interpreted to represent long term land regulation policies for each parcel in the region, in each year. The system for adjusting the regulations (or their interpretation) in different years was setup in the database, with the possibility of a different interpretation for each parcel for each year.

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2.10. Cost layers

A construction cost calculation system was built from the RS Means construction estimating product, with different costs by zip code and for different slopes. Consideration of costs to provide water and sewer to different areas was discussed, and the framework was setup to allow this, either as a future representation of real construction costs or a future representation of servicing policy useful to manage development.

2.11. Employment data

SCAG specific employment data was processed and used to allocate the IMPLAN activity totals to the SCAG zoning system.

2.12. Setup external import/export system

The external zones for integrating the SCAG economy with the rest of the world were setup, and the travel conditions reflecting transport disutility to the SCAG region were specified.

2.13. Hedonic rent models

The rents paid for space were available from a number of sources. A price model was constructed using a statistical procedure called a hedonic model. The specific model form used focuses on separating the zonal representative price from the parcel-specific price. The zonal level price is represented in the Activity Allocations (AA) module of the model, and accounts for the zone's location vis-à-vis other activity and the performance of the transportation system. The parcel-specific modifiers to the zonal-level price represent specifics of the parcel and the building on it, including building age the proximity effects related to noise, views, nuisance variables, and local pedestrian trips that cannot be represented in the zone-based transportation system.

2.14. Adjust space to match rents

The demand functions for space in the AA module were partially calibrated, and the base year allocation was set from employment and census data. With a demand

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function and a rent from the hedonic rent model, the supply can be caluclated to be consistent. A python script was written which repeatedly runs the base year AA module and adjusts the space in each zone until the estimated zonal-level price is reproduced by the model.

2.15.   Setup floorspace synthesizer

The floorspace used by the model must be consistent with employment and population, the model does not tolerate inconsistency in this regard each employee requires a place to work and each household requires a home. A floorspace synthesizer was used which reassigns space to each parcel to ensure this consistency, and provides for the categories that are used in the model. The floorspace synthesizer was adjusted to make maximum use of the parcel data, so that the "synthetic" built form resembles the "measured" built form.

2.16.   Adjust for trip length

The dispersion parameters for commodities in the AA module were adjusted so that commodity flow distances matched appropriate trip length distributions.

2.17.   Setup version control system

The Subversion system was setup to allow for version control of model input files. Accounts were created for SCAG staff.

2.18.   Setup rsync

A file-level synchronization system called "rsync" was setup which securly sends the changed portions of files to the HBA Specto server, so that the consultant can more easily review model results and assist with model troubleshooting and calibration.

2.19.   Install visualization system

A webserver based system for selecting model outputs at the LUZ and TAZ spatial level was written and installed. This compares outputs from PECAS across years and across scenarios, and creates a map on the website, which can be zoomed and panned. When the analyst is happy with the general content of the map, it can be easily opened

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in any GIS system that can read from the PostGIS database directly, as well as easily downloaded as an ESRI format .shp file for import into almost any GIS system. This provides a flexible system for using powerful third-party GIS software to generate final publication-quality maps, without the normal difficulty of pre-processing the data before it can be imported and viewed.

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3. Current PECAS SCAG model status

Current PECAS SCAG runs for four policy scenarios and has produced results which has been compared and revised for validation. Current tested scenarios include:

1. Baseline

2. 2 cent/mile Vehicle Millage Tax (VMT)

3. High Quality Transit Corridor (HQTC) - Case 1

4. High Quality Transit Corridor (HQTC) - Case 2 (allowing 20 times the development intensity in transit corridors in Los Angeles County)

PECAS SCAG Model is producing estimations by county for many variables. Outputs investigated here include:

- Floorspace for the year 2035

- Average annual rent increase (2007 - 2035)

- Transit oriented development capacity

- Households

- Jobs

- Residential floorspace

- Non-residential floorspace

The first three variables are presented comparing estimations between scenarios, and the rest are presented by scenario.

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3.1.   Estimated floorspace for 2035

Residential and non-residential floorspace has been predicted for different scenarios by county in the region. Each scenario has been compared against the baseline or the Base 1 scenario, as shown in **Error! Reference source not found.**. From the results it seems that the model is not particularly sensitive to the capacity of development.

Table 1: Floorspace estimation and comparison by county for year 2035

Type-County	Baseline 10^6 SQFT (A)	VMT Tax 10^6 SQFT (B)	Variation % (B)/(A)	HQTC 10^6 SQFT (C)	Variation % (C)/(A)	HQTC-2 10^6 SQFT (D)	Variation % (D)/(A)
RES – IMP	83.4	83.6	0.261	83.2	-0.170	82.7	-0.854
RES – LA	4,449.0	4,448.7	-0.006	4,464.5	0.349	4,513.1	**1.441**
RES – ORA	1,469.9	1,469.9	-0.004	1,472.5	0.175	1,469.5	-0.027
RES – RIV	1,053.5	1,053.8	0.031	1,056.0	0.240	1,051.3	-0.207
RES – SBN	933.2	932.7	-0.053	935.1	0.209	931.6	-0.164
RES – VEN	406.4	406.3	-0.025	406.4	0.005	406.1	-0.069
NONR – IMP	55.0	55.0	-0.055	54.9	-0.228	54.6	-0.773
NONR – LA	2,922.7	2,922.7	-0.002	2,930.6	0.269	2,958.0	1.205
NONR – ORA	1,085.2	1,085.2	0.001	1,087.0	0.163	1,084.0	-0.115
NONR – RIV	535.8	535.9	0.021	538.2	0.450	532.8	-0.551
NONR – SBN	479.9	479.9	-0.006	481.2	0.271	477.6	-0.484
NONR – VEN	238.5	238.5	-0.004	238.3	-0.081	238.0	-0.240

3.2.   Estimated average annual rent increase (2007 - 2035)

Average annual rent increase has been predicted for the four scenarios by county. Each scenario has been compared against the baseline and this comparison is shown from **Error! Reference source not found.** to Table 5.

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Table 2: Average annual rent increase - Baseline (%)

County	Residential	Non-Residential	Total
IMP	6.249	5.675	6.042
LA	5.190	5.677	5.367
ORA	5.680	6.115	5.827
RIV	5.593	6.660	5.902
SBN	5.948	5.588	5.822
VEN	5.781	5.959	5.840

Table 3:Average annual rent increase - VMT (%)

County	Residential	Non-Residential	Total	Ratio to Baseline		
				Residential	Non-Residential	Total
IMP	6.257	5.660	6.043	0.1272	-0.2695	0.0105
LA	5.192	5.677	5.368	0.0430	-0.0016	0.0251
ORA	5.680	6.115	5.827	0.0003	0.0069	0.0027
RIV	5.590	6.660	5.900	-0.0570	0.0004	-0.0356
SBN	5.947	5.588	5.822	-0.0130	0.0067	-0.0062
VEN	5.780	5.959	5.839	-0.0150	0.0086	-0.0066

Table 4: Average annual rent increase - HQTC (%)

County	Residential	Non-Residential	Total	Ratio to Baseline		
				Residential	Non-Residential	Total
IMP	6.199	5.611	5.987	-0.7959	-1.1346	-0.9044
LA	5.147	5.615	5.317	-0.8203	-1.0946	-0.9308
ORA	5.643	6.042	5.777	-0.6458	-1.1815	-0.8514
RIV	5.550	6.598	5.853	-0.7654	-0.9351	-0.8361
SBN	5.902	5.515	5.767	-0.7804	-1.3083	-0.9563
VEN	5.745	5.889	5.792	-0.6237	-1.1819	-0.8253

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Table 5: Average annual rent increase - HQTC-2 (%)

County	Residential	Non-Residential	Total	Ratio to Baseline		
				Residential	Non-Residential	Total
IMP	6.108	5.534	5.901	-2.2534	-2.4834	-2.3339
LA	5.070	5.549	5.244	-2.2981	-2.2408	-2.2759
ORA	5.588	5.952	5.709	-1.6210	-2.6612	-2.0171
RIV	5.472	6.512	5.772	-2.1613	-2.2196	-2.2019
SBN	5.824	5.414	5.681	-2.0918	-3.1131	-2.4332
VEN	5.689	5.803	5.725	-1.6010	-2.6149	-1.9664

From the results can be said that the direction of change matches our expectations and some improvements can be made in the model in order to get different answers from each county in the same scenario. Further detailed study about the rent pattern can be needed in order to improve the model.

3.3.   Transit oriented development capacity

Two scenarios were compared regarding transit oriented development: HQTC and HQTC-2, where density has been allowed to increase to 20 times as large only in LA county. Results shown that there are significant changes in LA county for both, residential and non-residential floorspace (Table 6).

Table 6: Transit oriented development capacity comparison.

Type-County	Parcel Land 10^6 SQFT (A)	Floor 10^6 SQFT (B)	FAR % (B)/(A)	Capacity 10^6 SQFT (C)	FAR to Capacity (B)/(C)	Scenario HQTC		Scenario HQTC-2	
						Capacity 10^6 SQFT (D)	Increment % (D)/(C)	Capacity 10^6 SQFT (E)	Increment % (E)/(C)
RES – IMP	266.8	65.3	24.5	133.4	49.0	133.4	0.00	133.4	0.00
RES – LA	9,793.1	4,339.4	44.3	5,076.0	85.5	5,376.8	5.93	11,092.0	118.52
RES – ORA	3,451.5	1,441.3	41.8	1,703.9	84.6	1,744.2	2.36	1,703.9	0.00
RES – RIV	2,602.7	917.3	35.2	1,354.3	67.7	1,375.1	1.54	1,354.3	0.00
RES – SBN	2,441.5	831.3	34.0	1,268.0	65.6	1,287.0	1.50	1,268.0	0.00
RES – VEN	1,065.2	384.4	36.1	518.1	74.2	519.0	0.18	518.1	0.00

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Type-County	Parcel Land 10^6 SQFT (A)	Floor 10^6 SQFT (B)	FAR % (B)/(A)	Capacity 10^6 SQFT (C)	FAR to Capacity (B)/(C)	Scenario HQTC		Scenario HQTC-2	
						Capacity 10^6 SQFT (D)	Increment % (D)/(C)	Capacity 10^6 SQFT (E)	Increment % (E)/(C)
NonR – IMP	515.3	43.2	8.4	249.2	17.3	249.2	0.00	249.2	0.00
NonR – LA	14,530.7	2,828.3	19.5	5,676.6	49.8	6,853.7	20.74	29,217.7	414.70
NonR – ORA	5,673.9	1,041.8	18.4	2,249.6	46.3	2,500.4	11.15	2,249.6	0.00
NonR – RIV	2,985.5	421.9	14.1	1,186.9	35.5	1,279.2	7.78	1,186.9	0.00
NonR – SBN	2,616.0	414.5	15.8	984.8	42.1	1,069.5	8.60	984.8	0.00
NonR – VEN	1,536.7	216.6	14.1	587.8	36.9	592.2	0.74	587.8	0.00

3.4. Baseline - reporting outputs

3.4.1. Households

A comparison between official forecast and PECAS estimation is shown by county for Households (Figure 1). The model is predicting the same large growth in Imperial, Riverside and San Bernardino as the official forecasts. The model predicts more growth in Orange County than the official forecast. The scales in the figures are different; although the shapes look similar in the figures the model predicts less differences between counties than the official forecast. This could be because the model is not sensitive enough to accessibility or prices, or it could be that the physical or legislative restrictions on development in the established counties (such as Orange County) are not adequately represented in the model inputs.

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Figure 1: Households - official forecast against PECAS estimations

Official Forecast (Trend + Local Input) Households by County (Ratio to 2007)
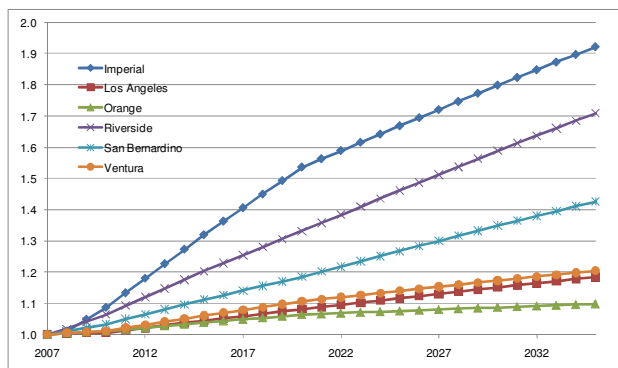
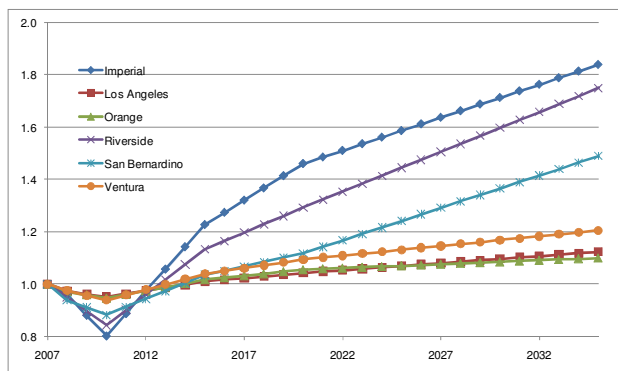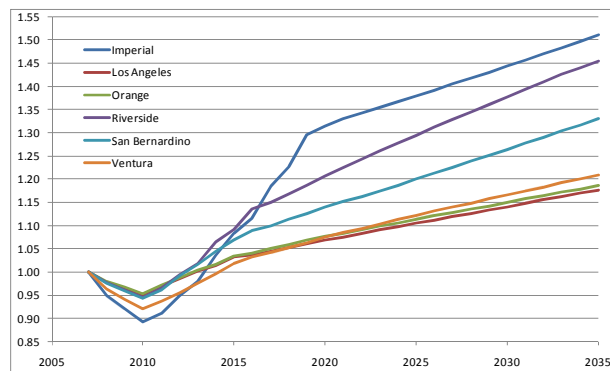PECAS Households by County – Baseline (ratio to 2007)
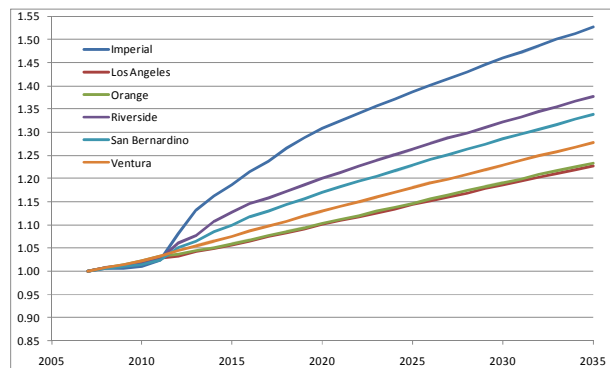
3.4.2. Jobs

A comparison between official forecast and PECAS estimation is shown by county for jobs (Figure 2). There is good general agreement between the model and the official forecast.

Figure 2: Jobs - official forecast against PECAS estimations

Jobs by County (Ratio to 2007)

PECAS estimated Jobs by County – Base 1 (Ratio to 2007)

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3.4.3. Floorspace

Floorspace estimations were also made by county, including total, residential and non-residential floorspace. PECAS output estimations by county are shown in Figure 3 and Figure 4.

Figure 3: Estimated Residential Floorspace (Base1 Case, Ratio to 2007 Square Feet)
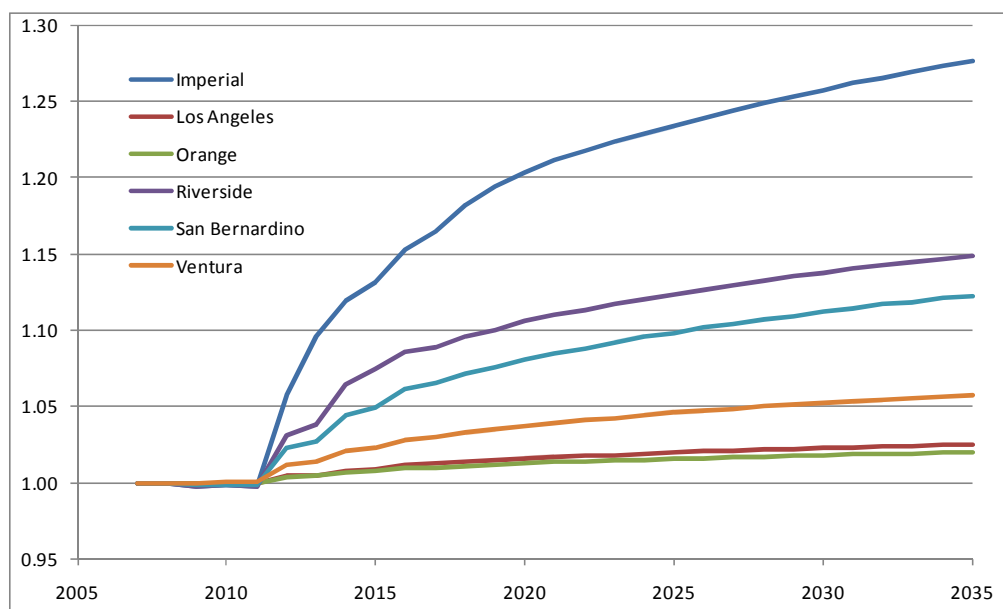
Figure 4: Non-residential Floorspace (Base1 Case, Ratio to 2007 Square Feet)

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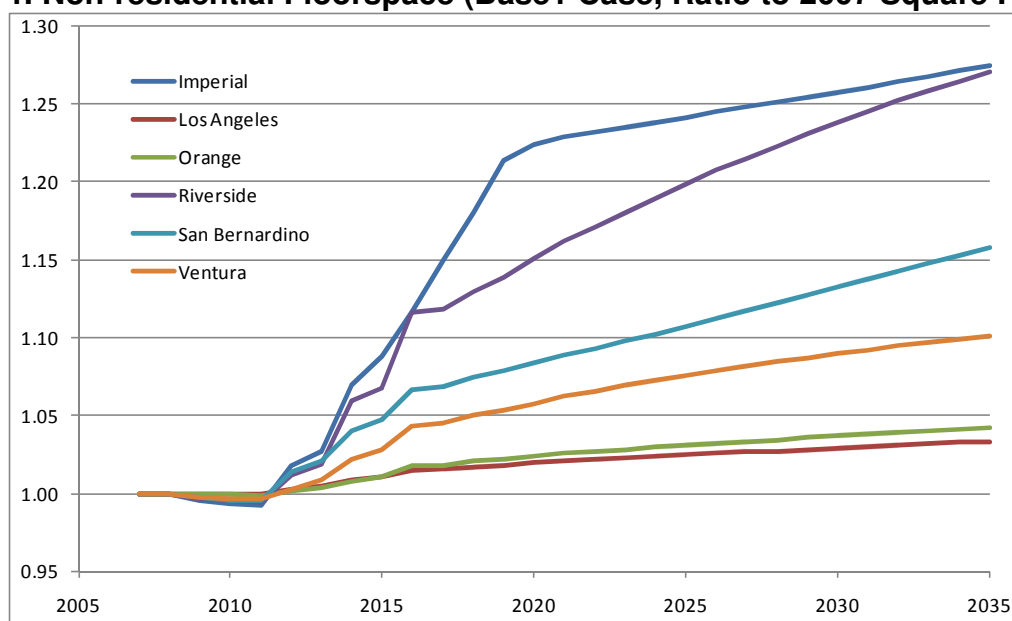
3.5. $0.02/ mile Vehicle Millage Tax- reporting outputs

For the rest of the scenarios (2 cents/mile VMT, HQTC and HQTC (case 2) a comparison between PECAS outputs against the baseline is presented. The comparison include estimations for households, jobs and floorspace (residential and non-residential). For the 0.02/mile scenario, outputs are as follows:

3.5.1. Households and Jobs

Estimations of households and jobs for 2 cents/mile VMT scenario are shown in Figure 5 and Figure 6. There is a large impact in Imperial County, the distance between Imperial County and the rest of the SCAG region becomes quite important in this scenario and Imperial County becomes more self-reliant and depends more on the external zones (e.g. Mexico and San Diego) than on the other internal SCAG zones.

Figure 5: HH by County (Difference from Base1, Percent)

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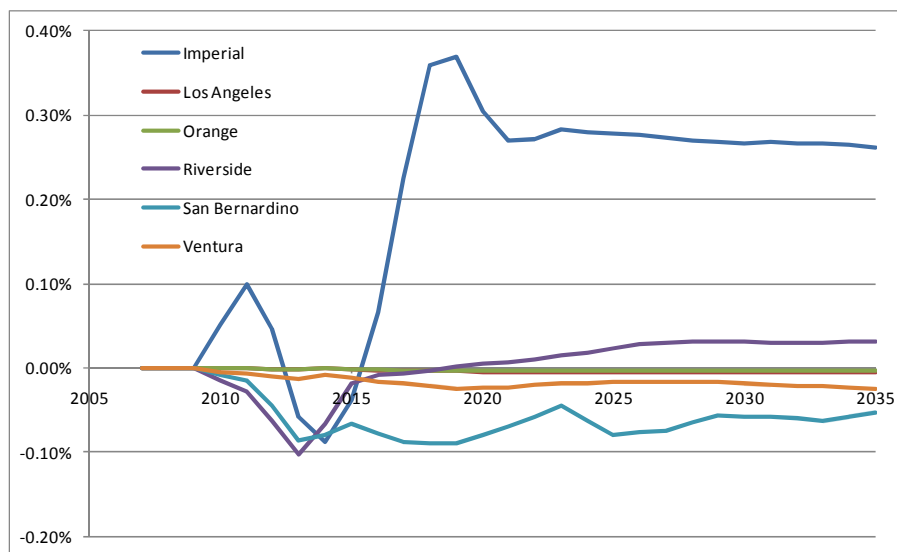File: SCAG status and next steps.doc
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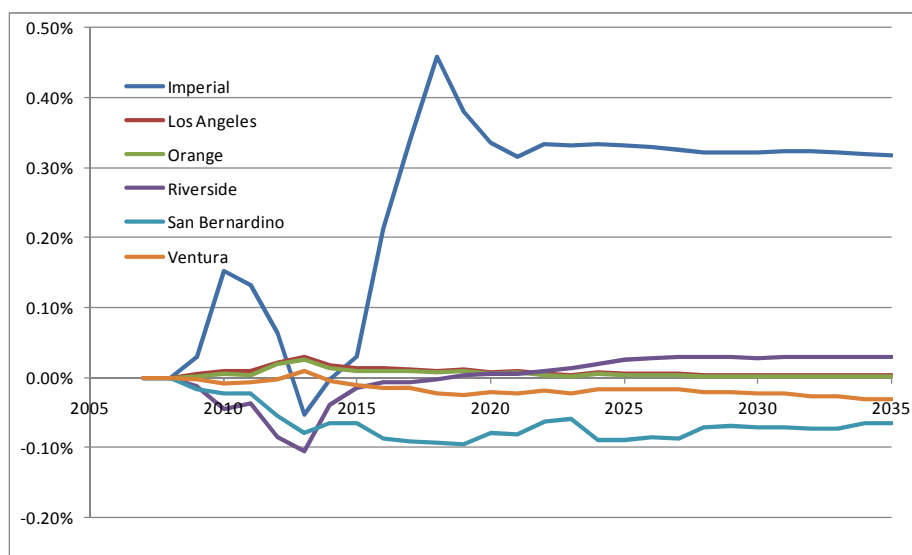
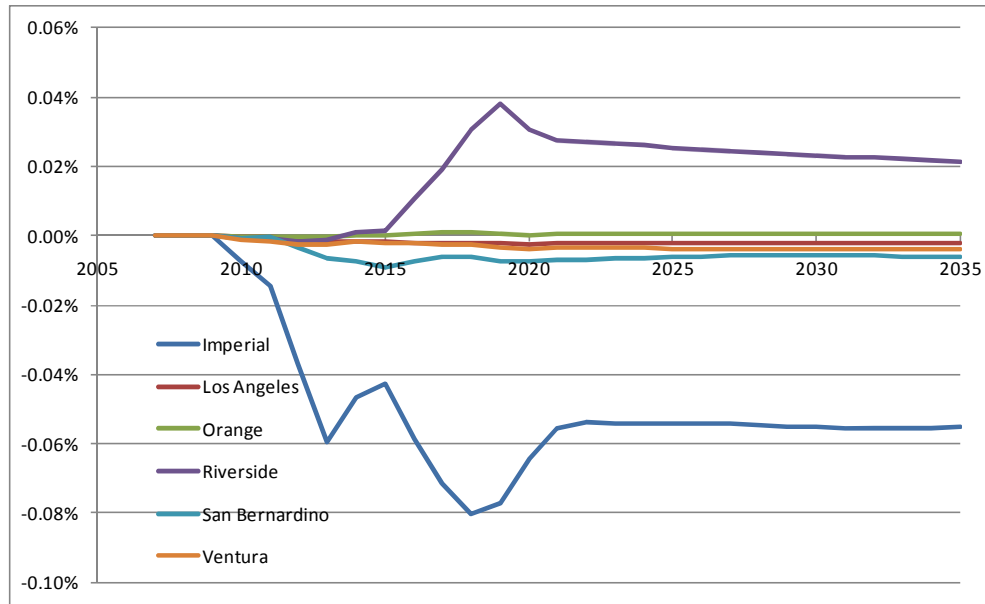**Figure 6: Jobs by County (Difference from Base1, Percent)**
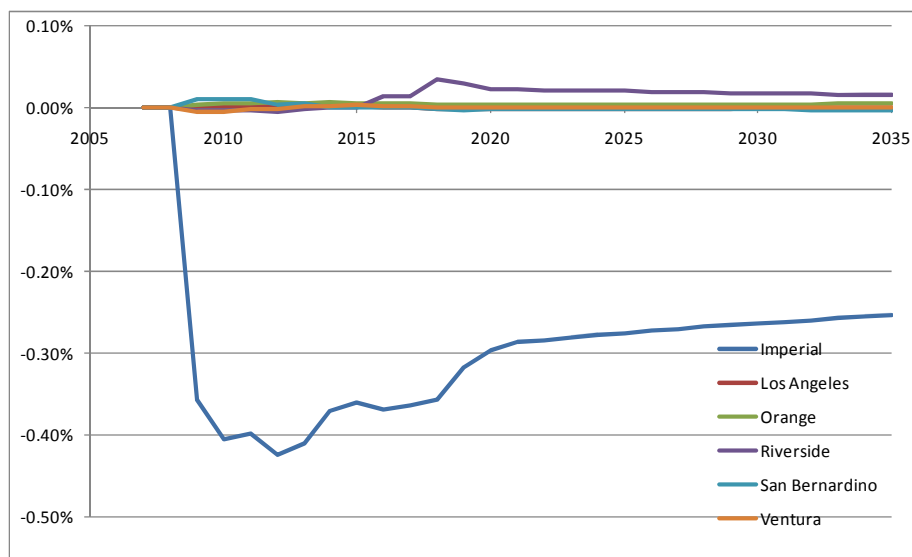
3.5.2. Floorspace

Estimated residential and non-residential floorspace are shown respectively in Figure 7 and Figure 8.

Figure 7:Residential space increment (Difference from Base1, Percent)

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Figure 8: Non-Residential space increment (Difference from Base1, Percent)

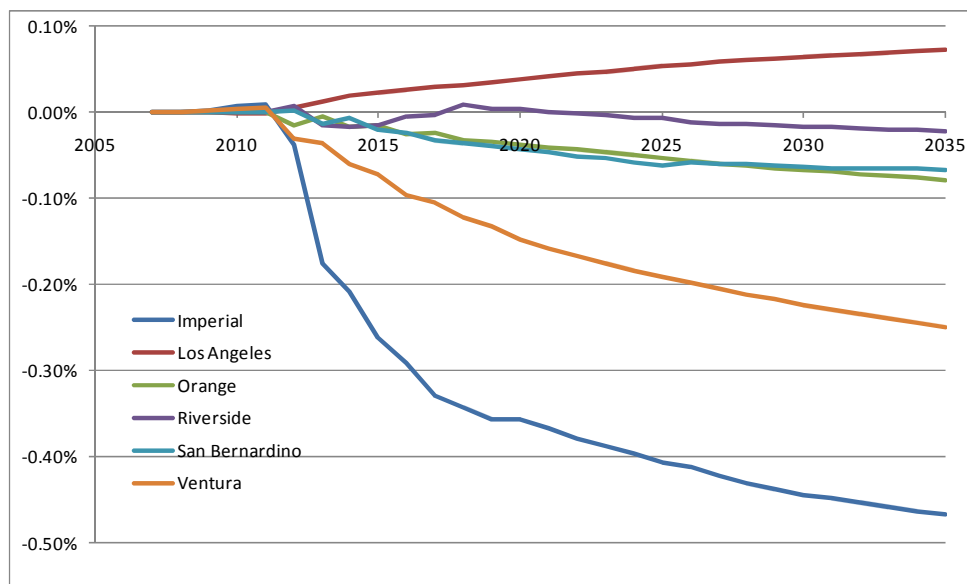### 3.6. HQTC (Case 1) - reporting outputs

3.6.1. Households

Estimations of households for HQTC scenario relative to the base scenario are shown in Figure 9. Los Angeles County becomes more attractive for residents in the HQTC scenario.
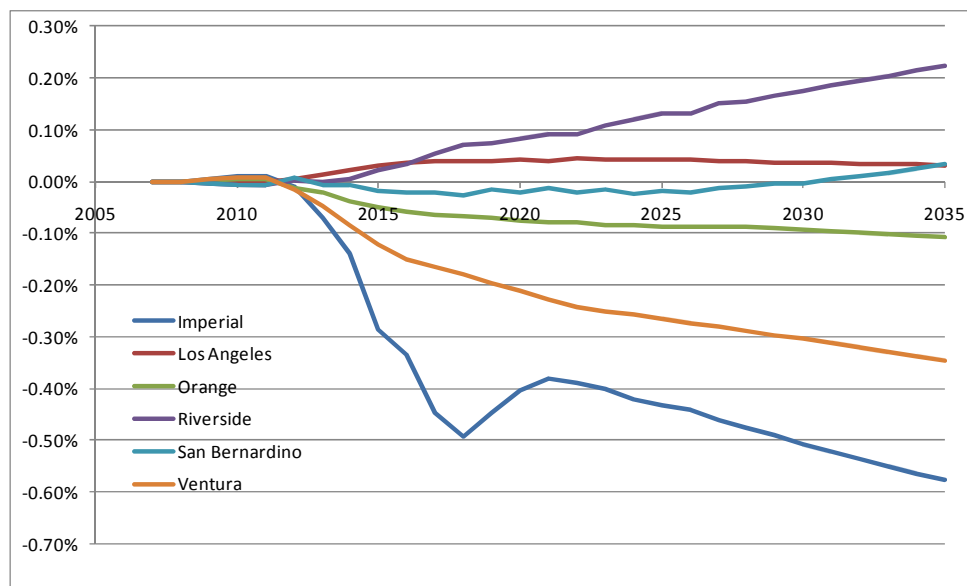
3.6.2. Jobs

Estimations of jobs for HQTC scenario relative to the base scenario are shown in Figure 10. Los Angeles county also becomes more attractive for jobs in this scenario. Riverside becomes more attractive for jobs, this should be further investigated to see which residents are attracted to jobs in riverside (by looking at PECAS's outputs regarding labor flow.)

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Figure 9: HH by County (Difference from Base1, Percent)

Figure 10: Jobs by County (Difference from Base1, Percent)

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3.6.3. Floorspace

Estimated residential and non-residential floorspace are shown respectively in Figure 11 and Figure 12. The pattern is not surprising although the magnitude of change is quite small.

Figure 11: Residential space increment (Difference from Base1, Percent)

Figure 12: Non-residential space increment (Difference from Base1, Percent)

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3.7.   HQTC (Case 2) - - reporting outputs

3.7.1. Households

Estimations of households for HQTC (case 2) scenario are shown in Figure 13. The increased capacity for construction in Los Angeles county has an obvious effect.
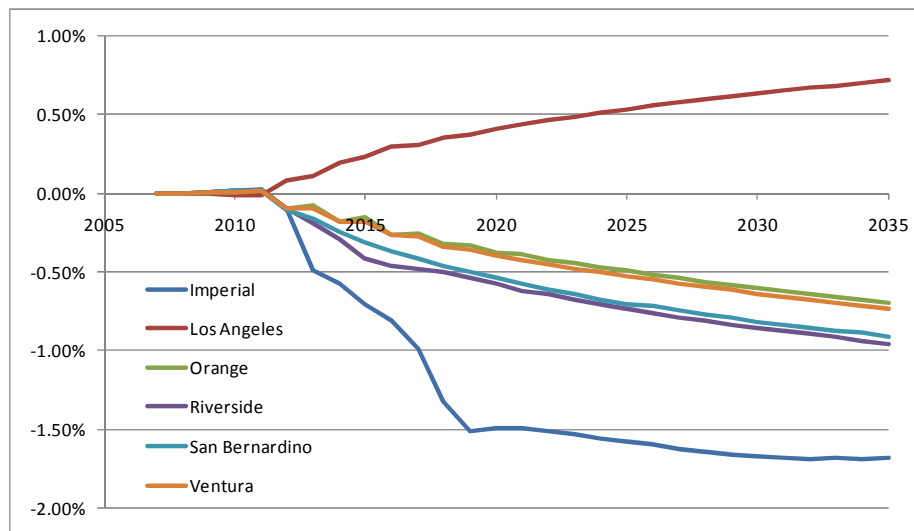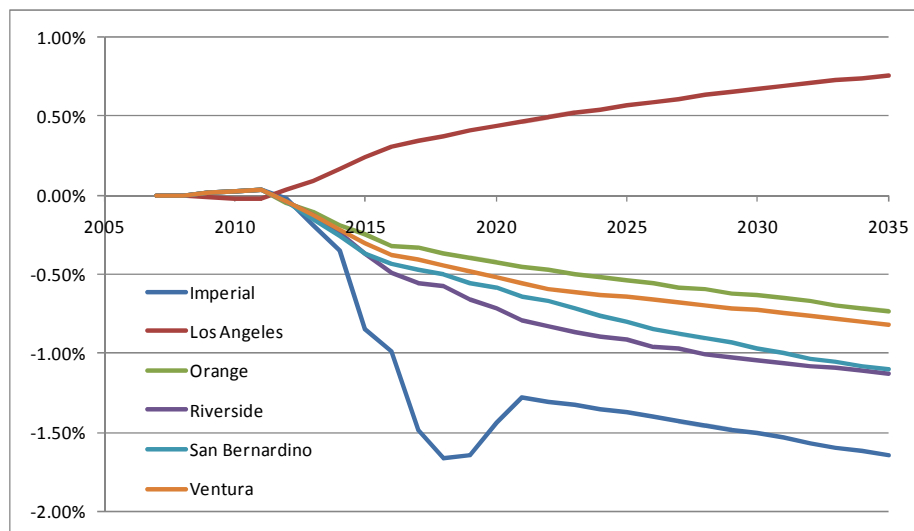
3.7.2. Jobs

Estimations of jobs for HQTC (case 2) scenario are shown in Figure 14. The increased capacity for construction in Los Angeles county has an obvious effect.

Figure 13: HH by County (Difference from Base1, Percent)

Figure 14: Jobs by County (Difference from Base1, Percent)

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4. Next steps in Model Development

The PECAS model for SCAG is being built in phases. The current model which has been described is useful for some purposes, but further development should occur to make the model more accurate and make it more useful.

One of the advantages of incremental model development is that effort can be refocused at various time points to improve those elements of the model that would benefit most from further work. Elements might benefit most for three reasons:

1. There is opportunity for a large improvement in an element with a low cost, because of resource (data or staff) availability
2. A particular element of the model has become particularly important to the agency, and the value of improvements has increased because of this agency focus, and
3. The model's current weaknesses with regard to an element are causing concern or problems.

This section identifies model elements that could benefit from further work, for one or more of these three reasons.

4.1. Thorough review different aspects of the results

This section of the report discusses certain elements of the model that were reviewed. The intention of the review was to identify and describe the biggest weaknesses in the model, for the purpose of prioritizing future model improvements. It is important to remember that this section focuses only on the largest weaknesses that were identified, not on model performance as a whole.

4.1.1. Unreasonable land use change estimation
Symptom

- Some minor land use types keep losing the amount over consecutive years of run, and eventually space amount goes to zero, while there is positive demand for the space at extremely high price.

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- Once such condition happens, the activity allocation model fails to carry on the multi-year run to the desired year.

- This could happen more frequently when current 302 zones are disaggregated into 531 zones.

- To prevent model from encountering such condition, initial space amount of the type have been set to be extremely high, and such input distorts initial activity allocation pattern.

Possible Causes

- The response of the simulation of development to rent in the model, which came from the setup version of statewide model, seems to be not appropriate for the SCAG region.

- More specifically, baseline rent in SCAG region is about 3 times higher than the median value (middle point) of the supply function.

- The statewide parameters in the activity allocation model are too insensitive to the rent, so excessive demand for the space type does not move to the other zones.

- The size term effects in the nested logit model do not scale exactly right when quantities are small (limitation of underlying theory).

Resolution

- Provide an interfering module to prevent any space types goes to zero amount (short term work-around).

- Update the space supply function to reflect actual SCAG rent level (longer term).

- Recalibrate the Activity allocation model regarding the elasticity of location response, by calibrating the Location Dispersion Parameter to longer term trends from census and employment data (long term).

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- Change size term treatment to better compensate for the underlying theory issue with the very small zones.

4.1.2. Even distribution of Growth

Symptom

- In the baseline, estimated increase rate of household and employment shows less differences between counties than the approved forecast.

- This symptom discounts the credibility of model since the approved forecast is fairly well accepted.

Possible Cause

- Growth is allocated to the infill (renovation) or development, net of demolition in each parcel.

- The sensitivity parameters in SD are too low, when each parcel is considered for development, the random process of in the space development model applies one set of region-wide transition probability to every parcel in the region, without enough impact from demand as reflected in the rent signals

- The sensitivity parameters in AA are too low, areas of low accessibility are considered only marginally less attractive than areas of high accessibility.

Resolution

- Instead applying the region-wide transition probability, create county-based transition probabilities, and run the space development model six times for each county. (Short-term).

- Provide additional spatial parameters for individual parcel level that could be used with the county-based transition probability, and incorporate into the space development model. (long-term).

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- Increase SD dispersion parameters in order to make it more sensitive to price.

- Increase AA dispersion parameters, so that more accessible areas generate higher price signals to SD.

4.1.3. Price variation

Symptom

- In the baseline run, annual increase rate of rent ranges from 5% to 6%, while the other input factors, such as wage and commodity show almost no price changes, with order of magnitude of 10^{-6}.

- This means that current model relies on only rent difference in the allocation of growth, with keeping other input factors price constant.

- Also, the impact of transportation cost could be exaggerated comparing to the moveable input factors in scenario tests.

Possible Cause

- Utility parameters that came from the statewide model may not best fit for the region.

- Especially, the parameters of utility function may be applicable to different order of magnitude of input variables from local. The state-wide model was calibrated based on county as a zone, while SCAG model uses CSA zone system, and the total activity in each zone should be much smaller than that from the state-wide model.

- Import and export functions can be too large. During model construction the imports and export functions are set larger than desireable, so that the "rest of the world" acts as a cushion for anything extreme happening in the model region. Certain types of calibration procedures are extreme, so

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these functions can remain large during early calibration but should be reduced to be more realistic in later calibration.

Resolution

- Adjust AA dispersion parameters.

- Calibrate import and export treatment.

4.1.4. Thorough review with scenarios runs

Symptom

- Scenarios analyzed so far could be categorized into 1) perturbed travel distance cost and 2) perturbed development capacity (density).

- So far, estimated impact from capacity increase seems too little based on expectations.

- However, it is not clear if the analyst's expectations are correct.

Resolution

- A literature review on empirical studies in Southern California is needed to verify the estimated sensitivity, to compare against actual data instead of expectations.

- In the case that current sensitivity is low than empirical studies, consider general plan variables in the developer's utility function.

- Identify parcels in TOD area, and provide special supply function (short term workaround).

- Ensure dispersion parameters (and resulting model sensitivity) are not too low by investigating data from SCAG region and findings from other PECAS models.

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4.2. Immediate tasks to improve the model

In the immediate future, several approaches can be taken to improve the model by resolving some issues. These can be undertaken by SCAG staff independently of consultant assistance:

1. Create an external module to prevent from any space type goes to zero amount
2. Try-out county based SD model runs
   a. Provide county based space transition parameters
   b. Run separate space supply models for each county
3. Try-out special supply function for the parcels in TOD area
   a. Special supply function will explicitly connect capacity to development
   b. Re-evaluate TOD scenario implementation method, and rerun

4.3. General approach to short term improvements and calibration

In the short term, the approach to improve the model involves the following general steps:

- Transfer the model run results (84 Gigabyte) for full review
- Further data provision for calibration, specifically process development data for six county space transition targets
- Assemble data for validation
- Review model parameters and targets for calibration
- Semi-automated model calibration for the updated parameters
- Perform scenario runs to test the new model

4.4. Specific medium term approaches

 This section lists some specific approaches and tasks that could be undertaken in the next phases of model development:

1. Review the initial model specifications and parameters from the state-wide model

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    a. Model specification review (according to available new statistics; zones, type of spaces, type of households and industries)

    b. Review the impact of statistics based on the statewide specifications, and replace with new regional statistics

2. List of parameters for recalibration and setup schedule

    a. Identify parameters, especially the ones from the state-wide model, and had not been updated in phase1

    b. Full model calibration

3. Scenario Tests

    a. Re-run scenarios that have been previously setup, compare results between scenarios.

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5. Conclusions

The land use forecasting and spatial economic model for SCAG has been constructed, installed, and begun it's process of calibration and improvement. The model is based on the PECAS (Production, Exchange, Consumption Allocation System) framework and is based on economic data on the relationships between households, firms and other institutions in the SCAG region, as well as interactions with the rest of the world.

The model has already undergone several rounds of improvement, to incorporate SCAG specific data, to move the Space Development (SD) module from a grid-based system to a parcel-based system, and to incorporate SCAG generated zoning regulations.

Several mechanical scripts for model calibration have been setup and SCAG staff have been trained in their operation. The model has proven to be adjustable to match data from the SCAG region regarding the willingness of the entities in SCAG to respond to future conditions and future policy.

The model results from several scenarios have been investigated and charts and maps have been produced to show the model results. These charts and maps have shown the types of output that will be useful from the model when it is used for forecasting and policy analysis. Some of the results show that the model is not yet responsive enough to certain inputs. A few key parameters have been identified for further calibration. These key parameters are best adjusted late in the modelling work, because seeing their full effect requires that much of the remaining system is both operational and partially calibrated. A strategy for this further calibration has been identified and described in Section 4.

The PECAS model is not yet fully integrated with SCAG's transportation demand models; travel conditions from SCAG's transportation models is used as input to PECAS but land use forecasts from PECAS are not yet used as inputs into the transportation models. The necessary work for this further integration has been

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identified. It should be noted that the exact relationship between the land use model and the transportation models depends on agency needs and the status of these models, both of which are changing. The intention is to remain flexible to best serve the agency.

Iterative development and flexibility are cornerstones of the model development strategy. This has been successful; SCAG's initial model was a simple parsing of the statewide model, and since then many advances have been made in response to feedback from SCAG staff and management. We hope to continue with this model development strategy.

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